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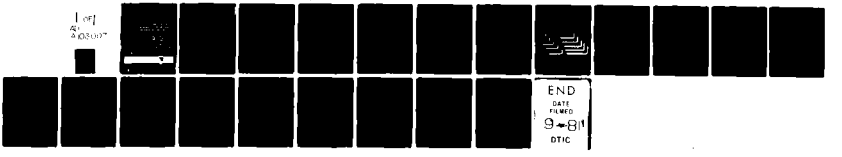

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CEMEL 228

EVALUATION OF CANDIDATE MATERIALS FOR SILHOUETTE LAYOUT MAT (SLM) FOR GENERAL MECHANICS TOOL KIT

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BY
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TEXTILE RESEARCH AND ENGINEERING DIVISION
COUNTERSURVEILLANCE AND CHEMICAL PRODUCTS BRANCH
CHEMICAL PRODUCTS SECTION

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TOOL KITS
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SILHOUETTE LAYOUT MATS (SLM'S)
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POLYESTER FIBERS
COATINGS
POLYESTER FILM LAMINATES
DURABILITY

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The purpose of the work was to find a material with suitable durability, acceptable color contrast, and good printability for fabrication of Silhouette Layout Mats to be used as inventory aids for Army tool sets, kits, and outfits.

Six different materials were chosen for engineering evaluation based on technical assessment of high success potential. Chemical and physical characteristics of candidate materials were established using laboratory tests chosen to simulate actual use conditions.

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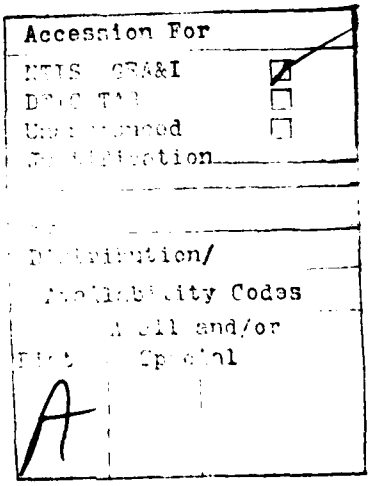
20. —Based on comparative results, one material, 150 denier polyester yarn/ polyurethane coated fabric, was recommended as the most suitable for the intended use. Concurrently, two methods of effecting corrections of a Silhouette Layout Mat made from the recommended material were identified.

Recommended material requirements, correction procedures, and potential material suppliers were developed.

PREFACE

The US Army Natick Research and Development Laboratories (NLABS) was tasked by Headquarters, US Army Materiel Development and Readiness Command (DARCOM) to perform the evaluation described in this technical report. The work was conducted at NLABS from September 1979 to June 1980 under Production Engineering Task - Engineering Support to DLA for Textiles, Leather, Rubber, Plastics and Findings for Combat Clothing and Footwear. PE Task Area was Q783029 and applicable work unit number was 930425791 30.



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EVALUATION OF CANDIDATE MATERIALS FOR
SILHOUETTE LAYOUT MAT FOR GENERAL MECHANICS TOOL KIT

1. BACKGROUND

Headquarters, The Adjutant General, Department of the Army (DA/TAG) identified a need for inventory aids for Army tool sets, kits, and outfits so that missing components could be quickly noted. The aids, or Silhouette Layout Mats (SLM's), would consist of a 48-inch by 36-inch sheet of base material on which full-size silhouettes of component tools are printed (see Figure 1.).

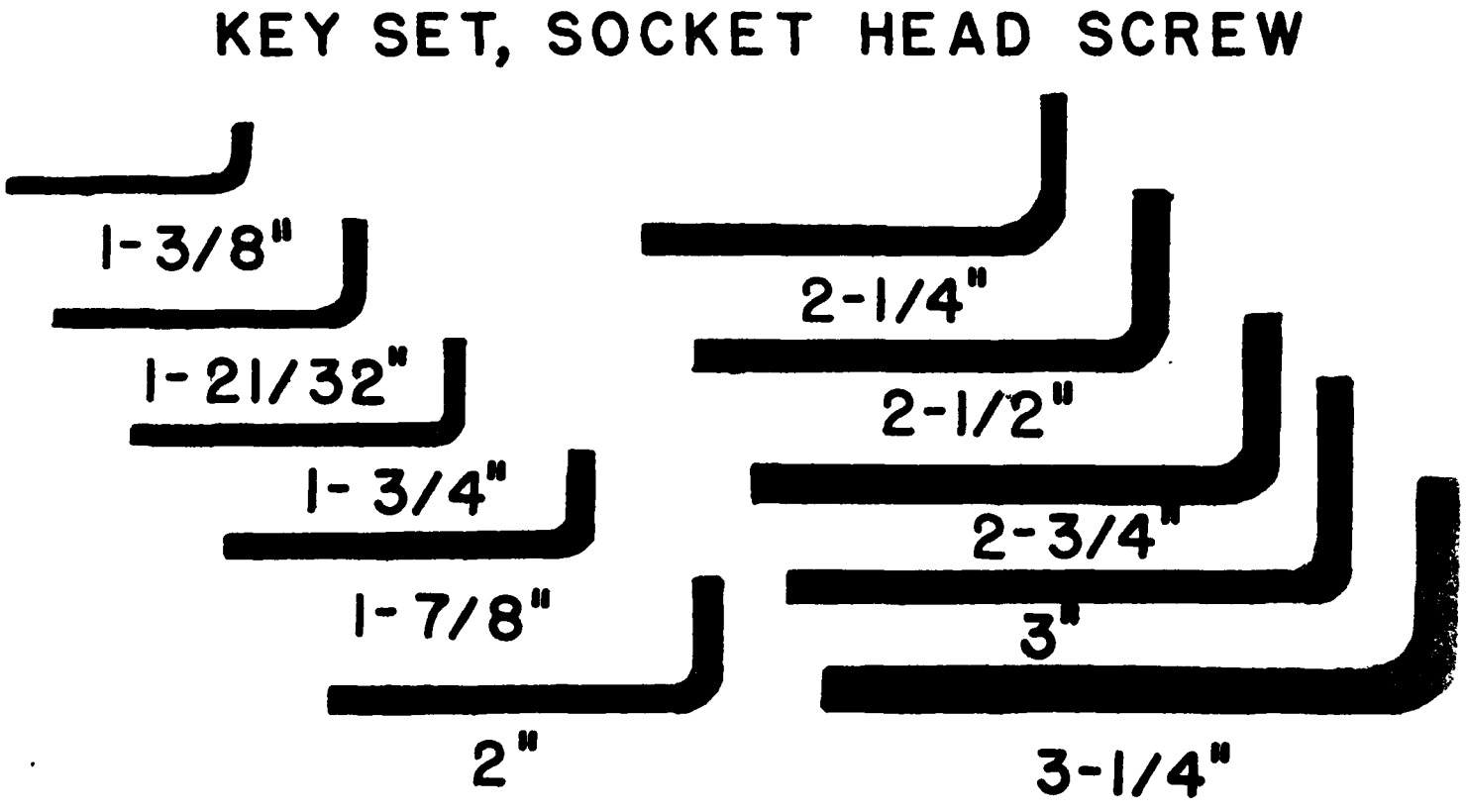


FIGURE 1. Section of SLM showing typical full-size silhouettes of representative components of the General Mechanics Automotive Tool Kit.

The SLM's are intended to be used at organizational direct levels of monthly maintenance, at which time they will be spread on a flat surface and have each component placed on the appropriate silhouette for accounting and inspection purposes. When not in use, each SLM would be folded to fit into the respective tool kit carrying case. The General Mechanics Automotive Tool Kit (NSN 5180-00-177-7033) was chosen for initial attention.

Headquarters, US Army Materiel Development and Readiness Command (DARCOM) tasked the US Army Natick Research and Development Laboratories (NLABS) to identify a suitable material that meets the durability, acceptable color contrast, and printing requirements for the desired SLM. NLABS was additionally tasked to present a procedure for updating the SLM to accommodate tool kit changes. Initially, HQ DARCOM furnished NLABS with a spun-bonded polyolefin (Tyvek) sheet printed with black silhouettes against a dark green background for evaluation. Five additional materials were chosen by NLABS based on technical judgment as having a good success potential.

2. CANDIDATE MATERIALS

a. Spun-bonded polyolefin (Tyvek) sheet coated with pyroxylin and printed with black silhouettes against a dark green background. Green and black printing overcoated with varnish.

b. A three layer polymer/paper/polymer laminate of the following construction: 0.5 mil texturized polyester film/65-lb kraft envelope paper/0.5 mil texturized polyester film. Silhouettes printed in black on the paper prior to lamination with the polyester film.

c. Same as b. above, except 75-lb kraft envelope paper base stock used in lieu of the 65-lb.

d. Same as b. above, except 92-lb kraft envelope paper base stock used in lieu of the 65-lb.

e. A 150-denier polyester filament yarn fabric, oxford weave, coated on both sides with a thermoset polyurethane coating to an approximate finished weight of 4 oz per sq yd. Silhouettes printed in black on the fabric prior to coating with polyurethane.

f. A 250-denier polyester filament yarn fabric, oxford weave, coated on both sides with a thermoset polyurethane coating to an approximate finished weight of 4 oz per sq yd. Silhouettes printed in black on the fabric prior to coating with polyurethane.

3. EVALUATION PROCEDURE/RESULTS

Physical and chemical laboratory tests, chosen to measure characteristics critical to the serviceability of the Silhouette Layout Mats, were conducted. Physical tests were performed in accordance with standard test methods used for

evaluation of textile and paper-based materials. Chemical tests were designed to simulate exposure to chemicals that could be encountered during the useful life of the SLM. Chemicals used included: water, solvents, oils, and fuels all of which are commonly found in vehicle maintenance environments.

Tables 1 through 6 list the characteristics tested, the test methods used, and the results obtained.

Results of physical and chemical tests show that the spun-bonded polyolefin sheet has excessive stiffness, and that the printed silhouettes on the surface exhibit poor resistance to abrasion and generally poor resistance to chemical reagents. This system is considered unsuitable for the intended use.

The polyester film/paper/polyester film laminates possessed adequate abrasion and chemical resistance. However, with the exception of the 65-lb paper laminate, they were excessively stiff or "boardy" at normal room temperatures which could cause a problem when folding the SLM for storage. All of the polyester film/paper/polyester film laminates showed a tendency to "wick" chemicals at the cut edges which would adversely effect the long term durability of the SLM. These materials are considered better than the spun-bonded polyolefin, and one, the 65-lb paper laminate, was rated "fair-to-good" for overall physical and chemical characteristics.

The polyurethane coated fabrics were superior to all candidate materials tested although they did exhibit increased stiffness when exposed to extreme cold temperatures of -20°F and -40°F. The 150-denier yarn fabric is considered to have a superior printing surface for volume production compared to the 250-denier yarn fabric.

Comparative ratings of the physical test results for all the candidate materials are listed in Table 7. Each material was rated as Excellent, Good, Fair, and Poor for each physical characteristic tested. Overall, the 150-denier polyester yarn fabric coated with polyurethane was rated the best of all the materials tested relative to stiffness, abrasion resistance, and printability. Chemical test results showed that polyurethane coated polyester yarn fabrics also have excellent resistance to chemical reagents of the types commonly found in vehicle maintenance areas.

4. CONCLUSIONS/RECOMMENDATIONS

a. Based on the comparative ratings of the physical tests and the results of the chemical tests, the 150-denier polyester yarn fabric coated with polyurethane is recommended for use as the base material for the Silhouette Layout Mat. For good color contrast consistent with visual camouflage considerations, it is recommended that the base material be dyed Army Tan Color 445 with the silhouettes printed in black. Clear, lusterless polyurethane coating would be applied over the printing to insure durability. Detailed material requirements are given in Appendix A.

TABLE 1. PHYSICAL TEST RESULTS OF SPUN BONDED POLYOLEFIN SHEET

Characteristic	Test Method[a]	Avg. Test Result
Overall weight, oz/yd^2	5041	3.9
Thickness, inch	5050	0.009
Breaking strength, lb	5100[b]	
Machine	—	163
Transverse	—	223
Tear strength, g	ASTM D 1922[bch]	
Machine	—	367
Transverse	—	320
Burst strength, lb	5120	177
Blocking, rating	5872[d]	No.2
Stiffness, cm	5204[e]	
@ 70°F		17.1
@ 40°F		21.6
@ 0°F		29.0
Abrasion resistance, cycles to visible base cloth:	5304[e]	
Abradant -		
Coated cloth (face)		2000
Polishing paper (emery 4/0)		200
Polishing paper (emery 0)		25
3M, Three-M-Ite Elek-Tro-Cut cloth, 240, J wt		25
Colorfastness to light[f] (Fadeometer)	5660	Pass
Weathering resistance[g] (Weatherometer)	5804	Pass

[a] FED-STD-191; Textile Test Methods, unless otherwise specified.

[b] Assumed short dimension of sheet is parallel to machine direction of cloth.

[c] Constant radius test specimen was used.

[d] Face side of coated cloth was tested.

[e] Test was conducted with the specimen and test apparatus in still air at the test temperature.

[f] Face side of coated sheet subjected to 140 hours exposure.

[g] Face side of coated sheet subjected to 120 hours exposure.

[h] American Society for Testing and Materials (ASTM) Standards.

TABLE 2. CHEMICAL TEST RESULTS OF SPUN BONDED POLYOLEFIN SHEET

Chemical	Percent Change in Weight (Immersion Test)[a]	Rating (Blocking Test)[b]	Rating[c] (Solubility Test)[d]
Water	0.0	No. 1	I
Alcohol - methyl alcohol	+ 27.6	No. 2	S
Ketones - acetone	- 1.4	—	S
Methyl ethyl ketone	- 1.4	No. 3	S
Cyclohexanone	+ 3.4	No. 2	S
Hydrocarbons -			
Aliphatic			
Mineral spirits	- 0.3	No. 1	SL
Aromatic			
Toluene	- 1.3	No. 2	S
Xylene	- 1.2	No. 2	S
Halogenated -			
Carbon tetrachloride	- 0.6	—	S
Acids -			
Sulfuric (37%)	+ 0.4	No. 1	I
Fuels -			
Mogas	0.0	No. 2	S
Diesel/Mogas mixture	+ 20.8	No. 1	SL
Oil - No. 3	+ 38.1	No. 1	I
Antifreeze - Ethylene glycol	+ 1.1	No. 1	I

[a] Specimens were weighed, immersed completely in the test solution for 10 min, removed and dried for 16 hours, and reweighed.

[b] Three drops of the test solution were placed in the center of a 4-by 8-inch sample of the coated cloth on the face side. The sample was folded to form a 4-by 4-inch square with the face side contacting itself. The folded square was placed between 4-by 4-inch glass plates and a 4-pound weight was placed on the assembly for 16 hours. The sample was then removed from between the glass plates and immediately rated for blocking as required in Method 5872 of FED-STD-191.

[c] Rating as follows:
I - insoluble; no removal of color, coating and printing
SL - slightly soluble; slight removal of color, coating and printing
S - soluble; complete removal of color, coating and printing.

[d] A piece of white color transfer cloth (Method 5651 of FED-STD-191) was saturated with the test solution and gently rubbed across the face side of the coated cloth.

TABLE 3. PHYSICAL TEST RESULTS OF POLYESTER FILM/PAPER/POLYESTER FILM LAMINATES

Characteristic	Test Method[a]	Average Test Result 65 lb	74 lb	92 lb
Overall weight, oz/yd^2	5041	4.5	4.8	5.8
Thickness, inch	5030	0.24	0.28	0.34
Breaking Strength, lb	5100[b]			
Machine		12.0	13.0	19.0
Transverse		23.3	11.5	21.0
Tear Strength, g	ASTM D 1922[b c]			
Machine		167	140	190
Transverse		208	140	180
Burst strength, psi	TAPPI T403[f]	81.4	80	106.4
Blocking rate	5872	No. 1	No. 1	No. 1
Stiffness, cm				
@ + 70°F		27.2	e	e
@ - 20°F		29.7	e	e
@ - 40°F		31	e	e
Abrasion resistance - cycles to base paper stock	5304			
Abradant				
1) Polishing paper (emery 4/0)		2000	2000	2000
2) Polishing paper (emery 0)		2000	2000	2000
3) 3M, Three-M-Ite Elek-Tro-Cut cloth, 240, J wt		25	25	25

[a] FED-STD-191, unless otherwise indicated.

[b] Assumed short dimension of sample is parallel to machine direction of paper.

[c] Constant radius test specimen used.

[d] Test specimens subjected to -40° ± 5°F for a period of 4 hours and tested in a still atmosphere at that temperature.

[e] Test not conducted due to insufficient material length.

[f] Technical Association of the Pulp and Paper Industry (TAPPI) Standards.

TABLE 4. CHEMICAL TEST RESULTS OF POLYESTER FILM/PAPER/POLYESTER FILM

Chemical	Percent Change in Weight (Immersion Test)[a] 65 lb	74 lb	92 lb	(Solubility Test)[b] 65 lb	74 lb	92 lb
Water	+ 0.3	+ 0.3	+ 0.3	I	I	I
Alcohol - methyl alcohol	- 1.4	+ 0.3	0	I	I	I
Ketones - acetone	- 0.9	- 1.8	+ 8.3	I	I	I
Methyl ethyl ketone	- 1.1	- 4.2	- 9.2	I	I	I
Cyclohexanone	+ 15	+ 16.1	+ 12.5	I	I	I
Hydrocarbons						
Aliphatic						
Mineral spirits	- 1.0	0	- 7.3	I	I	I
Aromatic						
Toluene	- 6.0	+ 0.14	+ 4.5	I	I	I
Keylene	+ 2.6	+ 1.5	+ 0.8	I	I	I
Halogenated						
Carbon tetrachloride	+ 4.4	+ 1.1	+ 0.2	I	I	I
Acids						
Sulfuric (37%)	c	c	c	S	S	S
Fuels						
Mogas	+ 2.0	+ 1.8	+ 0.9	I	I	I
Diesel/Mogas mixture	+ 10.7	+ 12.9	+ 10.0	I	I	I
Oil						
No. 3	+ 11.1	+ 15.1	+ 22.0	I	I	I
Antifreeze						
Ethylene glycol	+ 1.9	+ 2.5	+ 2.3	I	I	I

[a]Specimens were weighed, immersed completely in the chemical test solution for 10 minutes, removed, air dried for 16 hours, and reweighed.

[b]Rating as follows:
I - insoluble; no removal of plastic lamina
SL - slightly soluble; slight softening of plastic lamina
S - soluble; complete removal of plastic lamina.

[c]Specimens completely fragmented.

TABLE 5. PHYSICAL TEST RESULTS OF POLYURETHANE COATED FABRICS

Characteristic	Test Method[a]	Average Test Result 150 d	250 d
Overall weight, oz/yd^2	5041	4.3	4.2
Thickness, inch	5030	0.006	0.006
Breaking strength, lb	5100		
Warp		158	180
Filling		153	233
Tear strength, g			
Warp	5132	650	2320
Filling	5132	660	2950
Blocking rate	5872	No.1	No.1
Stiffness, cm	5204[b]		
@ + 70°F		9.5	12.6
@ - 20°F		16.2	15.3
@ - 40°F		18.4	17.9
Abrasion resistance - cycles to base fabric			
Abradant			
1) Polishing paper (emery 4/0)		2000	300-350
2) Polish paper (emery 0)		2000	300-350
3) 3M, Three-M-Ite Elek-Tro-Cut cloth, 240, J wt		15	15

[a] FED-STD-191, unless otherwise indicated.

[b] Test specimens subjected to -40° ± 5°F for a period of 4 hours and tested in a still atmosphere at that temperature.

TABLE 6. CHEMICAL TEST RESULTS OF POLYURETHANE COATED FABRICS

Chemical	Percent Change in Weight (Immersion Test)[a] 150 d	250 d	Rating (Solubility Test)[b] 150 d	250 d
Water	+0.2	-0.8	I	I
Alcohol - methyl alcohol	-0.7	-0.7	I	I
Ketones - acetone	-2.4	-2.4	I	I
Methylethyl ketone	-3.5	-2.4	I	I
Cyclohexanone	+1.5	+0.8	I	I
Hydrocarbons				
Aliphatic				
Mineral spirits	+0.3	+0.2	I	I
Aromatic				
Toluene	-0.5	-0.5	I	I
Keylene	-0.7	-0.7	I	I
Halogenated				
Carbon tetrachloride	+1.5	+0.5	I	I
Acids				
Sulfuric (37%)	c	c	S	S
Fuels				
Mogas	-0.3	-0.2	I	I
Diesel/Mogas mixture	+0.1	+1.0	I	I
Oil				
No. 3	+2.4	+5.2	I	I
Antifreeze				
Ethylene glycol	+1.4	+2.4	I	I

[a]Specimens were weighed, immersed completely in the chemical test solution for 10 minutes, removed, air dried for 16 hours, and reweighed.

[b]Rating as follows:

I — insoluble; no removal of the plastic coating

SL — slightly soluble; slight softening of plastic coating

S — soluble; complete removal of the plastic coating.

[c]Specimens completely fragmented.

TABLE 7. COMPARATIVE RATINGS OF PHYSICAL CHARACTERISTICS[a]

Characteristic	Candidate Materials: Polyester/Paper/Polyester 65 lb paper	74 lb paper	92 lb paper	Polyurethane Coated Fabric: 150 denier polyester yarn	250 denier polyester yarn	Spun Bonded Polyolefin
Overall weight	E	E	E	E	E	E
Thickness	F	F	P	E	E	G
Breaking strength	P	P	F	E	E	E
Tear strength	P	P	P	F	G	F
Burst strength	F	F	G	c	c	G
Blocking	E	E	E	E	E	P
Stiffness						
+ 70°F	F	b	b	E	G	F
- 20°F	F	b	b	E	F	P
- 40°F	F	b	b	F	F	P
Abrasion						
Polishing paper (emery 4/0)	G	G	G	G	P	P
Polishing paper (emery 0)	G	G	G	G	P	P
3M, 3M-Ite Elek-tro-cut cloth, 240 J wt.	F	F	F	P	P	P
Printability	E	E	E	E	G	G
Cost	G	G	G	G	G	P
Overall Rating	F - G	F	F	E	G	P

[a] E — Excellent
G — Good
F — Fair
P — Poor

[b] Test not conducted due to insufficient material length.

[c] Test not applicable to fabric.

b. Two relatively equal methods of correcting or revising a Silhouette Layout Mat of the recommended material have been identified:

(1) Pressure sensitive labels. Procure pressure sensitive paper labels, as needed, preprinted with the new silhouette pattern and coated to provide chemical and abrasion resistance. The labels would be distributed to the Army users of the tool kits for attachment to the existing SLM.

(2) Correction kit. Provide a correction kit to the tool kit user containing the following:

(a) an unprinted roll of the same polyurethane coated fabric as the SLM, for use as patches,

(b) a bottle of toluene solvent base cleaner,

(c) a squeeze tube of thermoplastic polyurethane compound adhesive,

(d) a permanent, waterproof, smear-proof, black vinyl-base ink marking pen.

This correction kit can be used in the field as follows:

(a) Cut a piece of fabric from the roll to extend 1/8 to 1/4-inch beyond the area of the silhouette to be corrected.

(b) Thoroughly clean the surface around the area to be corrected with toluene and permit to dry prior to applying the adhesive.

(c) Apply the adhesive to the face side of the SLM and spread evenly around the entire area to be corrected. The adhesive shall cover an area equal to the size of the correction patch.

(d) Apply an even coat of adhesive to one side of the correction patch.

(e) Allow adhesive on SLM and correction patch to dry until tacky.

(f) Center the patch over, and press firmly to, the area to be corrected, making sure that all edges of the correction patch are securely adhered to the SLM.

(g) Allow five minutes to dry.

(h) Trace new silhouette onto correction patch using black ink marker.

c. Recommended sources of supply for printed coated fabrics, coated fabric adhesives, preprinted pressure sensitive labels, and industrial markers are:

PRINTED COATED FABRICS

Kenyon Piece Dyeworks, Inc.
Kenyon, RI 02836
ATTN: Ms. M. Hindle
Tel: AC 401-364-7761

Putnam-Herzl
Canal Street
Putnam, CT 06260

Gibraltar Industries, Inc.
254-36th Street
Brooklyn, NY 11232
Tel: AC 212-965-6640

Bond Cote of Virginia, Inc.
P. O. Box 729
Burgis Avenue
Pulaski, VA 24301
Tel: AC 703-980-2640

Aldan Rubber Company
Tioga and Salmon Streets
Philadelphia, PA 19134
Tel: AC 215-739-6500

COATED FABRIC ADHESIVES

USM Corporation
Bostik Division
Middleton, MA 01949
Tel: AC 617-777-0100

3M Company
Industrial Specialties Div.
230-G265 3M Center
St. Paul, MN 55101
Tel: AC 612-733-7544

H. B. Fuller Company
2402 Kasota Avenue
St. Paul, MN 55108
Tel: AC 612-645-3401

PREPRINTED PRESSURE SENSITIVE LABELS

Dennison Manufacturing Company
Coated Paper Division
Framingham, MA 01701
Tel: AC 617-879-0511

Badger Tag & Label Corporation
85 Bentert Street
Random Lake, WI 53075
Tel: AC 414-944-4348

Contact Products, Inc.
9244 Markville Drive
Dallas, TX 75231
Tel: AC 214-231-6367

Converters, Incorporated
2671 Salmon Street
Philadelphia, PA 19125
Tel: AC 215-739-5605

INDUSTRIAL MARKERS

Sanford Corporation
2740 Washington Boulevard
Bellwood, IL 60104
Tel: AC 312-378-4814

Mark-Tex Corporation
163 Coolidge Avenue
Englewood, NJ 07631
Tel: AC 201-567-4111

Markall Products Company
4772-T W. 139th Street
Cleveland, OH 44135
Tel: AC 216-267-3235

John P. Nissen, Jr. Company
Glenside, PA 19038
Tel: AC 215-886-2025

Markal Company
270 N. Washtenaw Avenue
Chicago, IL 60612
Tel: AC 312-826-1700

APPENDIX A

PROPOSED MATERIAL REQUIREMENTS

FOR

SILHOUETTE LAYOUT MAT (SLM) FOR GENERAL MECHANICS TOOL KIT

Base Cloth. The base cloth shall be a 2.8-ounce per square yard oxford weave polyester cloth made using 150-denier polyester yarns. The color of the base cloth shall be Army Tan Color No. 445 and shall match the standard sample.

Silhouette Printing. The dyed base cloth shall be printed on one side only in the silhouette pattern. The color of the pattern shall be black.

Coated Cloth. The dyed and printed base cloth shall be coated equally on both sides with a suitably compounded, clear, dull, thermoset polyurethane coating compound. If plasticizers are required, only phosphate or phthalate ester plasticizers shall be used. The finished coated cloth shall meet all of the physical and chemical requirements shown in Table 1 when tested as specified in Table 1.

TABLE 1. COATED CLOTH REQUIREMENTS AND TEST METHODS

Characteristic	Requirement		Test Method[a]
	Min.	Max.	
Weight, oz/yd^2	4.0	4.5	5041
Breaking strength, lb			
Warp	140	-	5100
Filling	140	-	5100
Tearing strength, g			
Warp	600	-	5132
Filling	600	-	5132
Blocking, rating	-	No. 2	5872
Stiffness, warp only, cm			
at +70° ± 2°F	-	11.0	5204
at -40° ± 5°F	-	20.0	5204[b]
Abrasion resistance	c		5304[d]
Resistance to solvents, percent change			
Acetone	-	3.0	e
Toluol	-	1.0	e

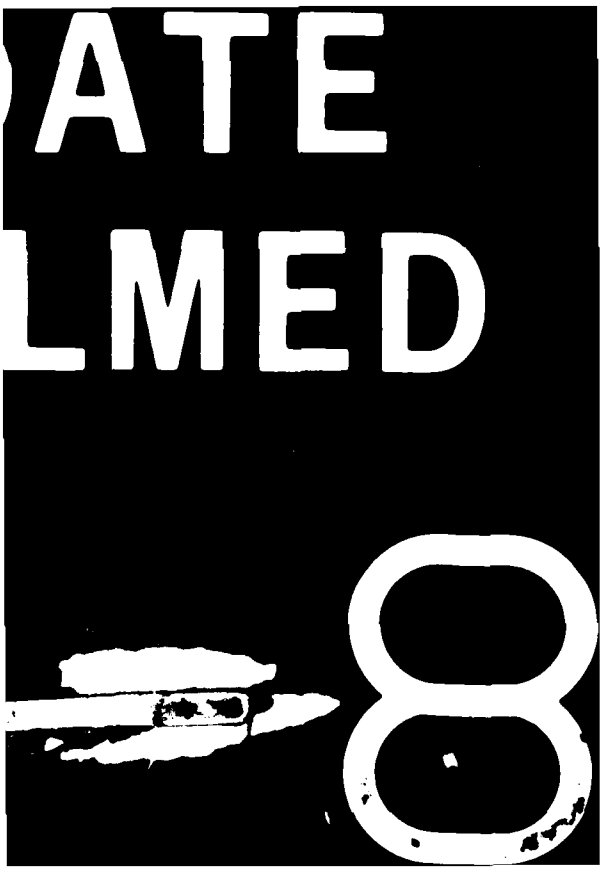
[a]Unless otherwise specified, methods of test specified in FED-STD-191 shall be used.

[b]The test specimens shall be subjected to a temperature of $-40^{\circ} \pm 5^{\circ}F$ for a minimum of 4 hours and the test shall be performed in a still atmosphere at that temperature.

[c]The coating shall not be abraded from the coated cloth exposing the printed base cloth in the center 1 inch of the abraded portion.

[d]Three specimens of the coated cloth with long dimension parallel to the warp shall be abraded on the face side for 2000 cycles using Emery 0 polishing paper. The load shall be 3 pounds and the tension shall be 6 pounds.

[e]Five specimens of the coated cloth shall be weighed and then immersed completely in the chemical solvent for 10 minutes. At the end of the exposure period, the specimens shall be removed from the solvent, air-dried for 16 hours and then reweighed. The percent weight change shall be calculated on the basis of the initial, unexposed specimen weight to the nearest 0.1 percent.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